Introduction

This book deals broadly with the topic of structures related to buildings. Emphasis is placed on the concerns of the working, professional designers who must cope with the practical problems of figuring out how to make plans for the construction of good, practical, and sensible buildings. Designers' concerns range from a basic understanding of structural behaviors to the determination of the construction details for a specific type of building.

The materials in this book are arranged to present a logical sequence of study. However, it is to be expected that few readers will start at page 1 and proceed to the end, as if reading a novel. The separate book chapters are therefore developed as reasonably freestanding, with appropriate referencing to other chapters for those readers who need some reinforcement. Additionally, at any time, the reader can use the Table of Contents, the Index, or the Glossary to seek help in understanding unfamiliar terms or ideas.

This book is intended for possible use as a course text but is also prepared to be used for individual self-study. In fact, even in a classroom situation where time is limited, students may well require considerable time for self-study outside the classroom.

Whether required as homework assignments or not, the exercise problems provided for individual book sections should be used by readers to test their own comprehension and problem-solving skills. For this self-study effort, answers to the problems are given, although readers should first attempt to solve the problems without recourse to the answers. Skill in performing computational work cannot be achieved by simply following a text example; the problems must be faced by the unassisted reader.

COMPUTATIONS

Structures for buildings are seldom produced with a high degree of dimensional precision. Exact dimensions of some parts of the construction—such as window frames and elevator rails—must be reasonably precise; however, the basic structural framework is ordinarily achieved with only a very limited dimensional precision. Add this to various considerations for the lack of precision in predicting loads for any structure, and the significance of highly precise structural computations becomes moot. This makes a case for not being highly concerned with any numbers beyond about the second digit (103 or 104; either will do).

While most professional design work these days is likely to be done with computer support, most of the work illustrated here is quite simple and was actually performed with a hand calculator (the eight-digit, scientific type is quite adequate).

SYMBOLS

The following symbols are used in this book.

Symbol	Reading
$>$	Is greater than
$<$	Is less than
$\geq$	Equal to or greater than
$\leq$	Equal to or less than
$6'$	Six feet
$6''$	Six inches
$\sum$	The sum of
ΔL	Change in L

STANDARD NOTATION

Notation used in this book complies generally with that used in the design and construction fields and the latest editions of standard specifications. The following list includes the notation used in this book and is compiled from more extensive lists in the references. Additional notation is explained in various chapters in this book.

A Area, general
A_g Gross area of a section, defined by the outer dimensions
A_n Net area (gross area less area removed by holes or notches)
C Compressive force
C_D Load duration factor
C_F Size factor for sawn lumber
C_M Wet (moisture) service factor
C_P Column stability factor
C_T Buckling stiffness factor for dimension lumber
C_r Repetitive member factor for dimension lumber
D Diameter
E Reference modulus of elasticity
E' Adjusted modulus of elasticity
$E_{\min}$ Modulus of elasticity for stability investigation
F_b Reference bending design value
F_b' Adjusted bending design value
F_c Reference compressive design value parallel to the grain, due to axial load only
F_c' Adjusted compressive design value parallel to the grain, due to axial load only
F_{cE} Design value for critical buckling in compression members
$F_{c\perp}$ Reference compression design value perpendicular to the grain
$F_{c\perp}'$ Adjusted compression design value perpendicular to the grain
F_v Reference shear design value parallel to the grain
F_v' Adjusted shear design value parallel to the grain
G Specific gravity
I Moment of inertia, or importance factor (wind and earthquakes)
L Length (usually of a span), or unbraced height of a column
M Bending moment
M_r Reference design moment
M_r' Adjusted design moment

P	Concentrated load or axial compression load
Q	Statical moment of an area about the neutral axis
R	Radius of curvature
S	Section modulus
T	Temperature in degrees Fahrenheit, or tension force
V	Shear force, or vertical component of a force
V_r	Reference design shear
V'_r	Adjusted design shear
W	Total gravity load, or weight, or dead load of an object, or total wind load force, or total of a uniformly distributed load or pressure due to gravity
b	Width or breadth of bending member
c	In bending: distance from extreme fiber stress to the neutral axis
d	Overall beam depth, or pennyweight of nail
e	Eccentricity of a nonaxial load, from the point of application of the load to the centroid of the section
f_b	Actual computed bending stress
f_c	Actual computed compressive stress due to axial load
f'_c	Specified compressive strength of concrete
f'_m	Specified compressive strength of masonry
f_p	Actual computed bearing stress
f_t	Actual computed stress in tension parallel to the grain
f_v	Actual computed shear stress
r	Radius of gyration
s	Spacing of objects, center to center
t	Thickness, general
w	Unit of a distributed load on a beam (lb/ft, etc.)

Greek Letters

Δ (delta)	1. Deflection, usually maximum vertical deflection of a beam; 2. indication of "change of" in mathematical expression
$\sum$ (sigma)	Sum of
λ (lambda)	1. Time effect factor (LRFD); 2. adjustment factor for building height (wind)
ϕ (phi)	Resistance factor (LRFD)

UNITS OF MEASUREMENT

Previous editions of this book have used U.S. units (feet, inches, pounds, etc.) for the basic presentation. In this edition the basic work is developed with U.S. units with equivalent metric (SI) unit values in brackets [thus].

Table 1 lists the standard units of measurement in the U.S. system with the abbreviations used in this work and a description of common usage in structural design work. In similar form, Table 2 gives the corresponding units in the metric system. Conversion factors to be used for shifting from one unit system to the other are given in Table 3. Direct use of the conversion factors will produce what is called a *hard conversion* of a reasonably precise form.

In the work in this book many of the unit conversions presented are *soft conversions*, meaning ones in which the converted value is rounded off to produce an approximate equivalent value of some slightly more relevant numerical significance to the unit system. Thus a wood 2 by 4 (actually 1.5 × 3.5 in. in the U.S. system) is precisely 38.1 mm × 88.9 mm in the metric system. However, the metric equivalent "2 by 4" is more likely to be made 40 × 90 mm—close enough for most purposes in construction work.

Table 1 Units of Measurement: U.S. System

Name of Unit	Abbreviation	Use in Building Design
Length		
Foot	ft	Large dimensions, building plans, beam spans
Inch	in.	Small dimensions, size of member cross sections
Area		
Square feet	ft^2	Large areas
Square inches	$in.^2$	Small areas, properties of cross sections
Volume		
Cubic yards	yd^3	Large volumes, of soil or concrete (commonly called simply "yards")
Cubic feet	ft^3	Quantities of materials
Cubic inches	$in.^3$	Small volumes
Force, Mass		
Pound	lb	Specific weight, force, load
Kip	kip, k	1000 lb
Ton	ton	2000 lb
Pounds per foot	lb/ft, plf	Linear load (as on a beam)
Kips per foot	kips/ft, klf	Linear load (as on a beam)
Pounds per square foot	lb/ft^2, psf	Distributed load on a surface, pressure
Kips per square foot	k/ft^2, ksf	Distributed load on a surface, pressure
Pounds per cubic foot	lb/ft^3	Relative density, unit weight
Moment		
Foot-pounds	ft-lb	Rotational or bending moment
Inch-pounds	in.-lb	Rotational or bending moment
Kip-feet	kip-ft	Rotational or bending moment
Kip-inches	kip-in.	Rotational or bending moment
Stress		
Pounds per square foot	lb/ft^2, psf	Soil pressure
Pounds per square inch	$lb/in.^2$, psi	Stresses in structures
Kips per square foot	$kips/ft^2$, ksf	Soil pressure
Kips per square inch	$kips/in.^2$, ksi	Stresses in structures
Temperature		
Degree Fahrenheit	°F	Temperature

Table 2 Units of Measurement: SI System

Name of Unit	Abbreviation	Use in Building Design
Length		
Meter	m	Large dimensions, building plans, beam spans
Millimeter	mm	Small dimensions, size of member cross sections
Area		
Square meters	m^2	Large areas
Square millimeters	mm^2	Small areas, properties of member cross sections
Volume		
Cubic meters	m^3	Large volumes
Cubic millimeters	mm^3	Small volumes
Mass		
Kilogram	kg	Mass of material (equivalent to weight in U.S. units)
Kilograms per cubic meter	kg/m^3	Density (unit weight)
Force, Load		
Newton	N	Force or load on structure
Kilonewton	kN	1000 N
Stress		
Pascal	Pa	Stress or pressure (1 Pa = 1 N/m^2)
Kilopascal	kPa	1000 Pa
Megapascal	MPa	1,000,000 Pa
Gigapascal	GPa	1,000,000,000 Pa
Temperature		
Degree Celcius	°C	Temperature

Table 3 Factors for Conversion of Units

To Convert from U.S. Units to SI Units, Multiply by:	U.S. Unit	SI Unit	To Convert from SI Units to U.S. Units, Multiply by:
25.4	in.	mm	0.03937
0.3048	ft	m	3.281
645.2	$in.^2$	mm^2	1.550×10^{-3}
16.39×10^3	$in.^3$	mm^3	61.02×10^{-6}
416.2×10^3	$in.^4$	mm^4	2.403×10^{-6}
0.09290	ft^2	m^2	10.76
0.02832	ft^3	m^3	35.31
0.4536	lb (mass)	kg	2.205
4.448	lb (force)	N	0.2248
4.448	kip (force)	kN	0.2248
1.356	ft-lb (moment)	N-m	0.7376
1.356	kip-ft (moment)	kN-m	0.7376
16.0185	lb/ft^3 (density)	kg/m^3	0.06243
14.59	lb/ft (load)	N/m	0.06853
14.59	kips/ft (load)	kN/m	0.06853
6.895	psi (stress)	kPa	0.1450
6.895	ksi (stress)	MPa	0.1450
0.04788	psf (load or pressure)	kPa	20.93
47.88	ksf (load or pressure)	kPa	0.02093
$0.566 \times (°F - 32)$	°F	°C	$(1.8 \times °C) + 32$